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INTRODUCTION

An electron-nucleus (e-A) collider with center-of-mass energy in excess of 50 GeV per electron-nucleon collision will allow the physics community to obtain unprecedented new knowledge of the partonic structure of nuclei. If reliable information is to be extracted on these partonic densities, it is essential to realize that with our current level of understanding of QCD, momentum transfers to the struck partons greater than 1 GeV/c are necessary. This requirement puts a priority on high center-of-mass energy if partonic densities are to be measured over a wide range.

Comparing the partonic structure of the free nucleon to that of bound nucleons and measuring the systematic changes in that structure as a function of nucleon number (A) will provide deeper insight into the origins and dynamics of nuclear binding. In addition, e-A collisions will allow the exploration of partonic densities appreciably higher than is accessible in e-p collisions. An e-A collider will allow one to measure the gluonic structure functions of nuclei down to $x \sim 10^{-3}$, information valuable in its own right and essential to a quantitative understanding of highly relativistic A-A collisions.

The time-space evolution of partons can only be investigated by studying the modifications of hard collisions that take place when nuclear targets are employed. In a hard collision the partonic fragments interact, hadronize, and reinteract on their way to the distant detectors without revealing their evolution into the hadrons finally detected. Nuclear targets of differing A place varying amounts of nuclear matter in proximity to the hard collision producing unique information about the quantum fluctuations of incident projectile prior to the collision and on the early evolution of the produced partons.

Using charged leptons (e,μ) to investigate this physics has been the richest source of information to date and extending the reach of these investigations by the constructing an e-A collider is the best opportunity within reach of the US nuclear science community. This work will potentially affect all areas of strong interaction research. A host of additional issues of considerable interest to nuclear scientists can be investigated; some of which are discussed below.

DIS KINEMATICS AND THE ADVANTAGES OF A COLLIDER

Research with e-A collider has two major advantages over fixed target studies. First, a collider delivers more energy to the center of mass, providing greater range in x and Q^2 in the primary collisions, and second, final states of the target may be observed that are typically inaccessible to fixed target experiments.

The energy in the center of mass squared (s) of a two-body collision is a relativistic invariant given by

$$s = \left(p_L + p_N\right)^2 \ , \tag{1}$$

which for an energetic lepton (p_L) incident on a nucleon (p_N) at rest is

$$s_F^{1/2} = \left(2M_N\, p_L\right)^{1/2} \ . \tag{2}$$

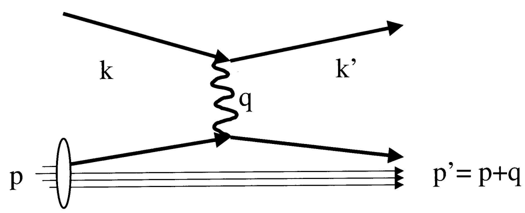
Thus, for a 25 GeV lepton, $s_F^{1/2}$ = 6.8 GeV. In the collider mode $s^{1/2}$ is given by,

$$s_C^{1/2} \approx \left(4\, p_L\, p_N\right)^{1/2} \ . \tag{3}$$

Thus, a 10 GeV electron colliding with a 30 GeV proton produces $s_C^{1/2}$ = 34.6 GeV. The increase in energy by employing a collider is evident. It is impractical, to say the least, to provide a 600 GeV electron beam to achieve the equivalent center-of-mass energy on a fixed target.

Figure 1 depicts the kinematics of a deep inelastic scattering (DIS) between a nucleon and a charged lepton. E and E' are the COM energies of the scattered lepton. The fraction of the nucleon's momentum, carried by the struck parton is x. The fraction of lepton energy given up in the collision is y. Requiring that Q^2 > 1 GeV^2, the lowest value useful value of x that can be accessed is $x_{\min} \approx$ *1/ 0.9s.* At e-RHIC with 10 GeV electrons and nuclear beams of 100 GeV/nucleon, $x_{\min} \approx 3\times10^{-4}$.

A collider also allows much more effective measurement of the final states of the target than is the case for fixed target experiments. Fixed target exclusive and semi-inclusive measurements are forced to employ "thin" targets (less than an interaction length) if nuclear fragments are to escape the target. The use of requisitely thin targets reduces the luminosity, making the acquisition of sufficient statistics a serious problem. Further, the boost acquired by target fragments in the collider mode makes them readily detectable when they separate from the beam.



$$Q^2 = - q \cdot q = 4EE' \sin^2\theta/2$$

$$x = Q^2 / 2\, p \cdot q \qquad y \equiv p \cdot q / p \cdot k$$

$$x \approx Q^2 / yS$$

Useful range:

$$x_{min} = 1/0.9S = 3x10^{-4}\ (e\text{-}A)$$

$$=10^{-4}\ (\text{e-p})$$

Figure 1. Collider DIS kinematics.

PREVIOUS FIXED TARGET EXPERIMENTS

To better understand how an e-A collider can advance our knowledge of the partonic structure of nuclei, it is useful to briefly examine the e-A and μ-A DIS experiments that have been carried out in the fixed target mode.

The highest energy DIS experiments on nuclei used tertiary beams of muons on fixed nuclear targets. The NMC [1,2] series of experiments at CERN were carried out at $s^{1/2}$ = 23.7 GeV, and those of E-665/FNAL [3,4] at $s^{1/2}$ = 30.6 GeV. The muon intensities were typically 2×10^6 μ/s and employing thick nuclear targets of 600 g/cm^2 targets achieved luminosities of 6×10^{32} cm^{-2}s^{-1}nucleon^{-1}. These thick targets are only practical for inclusive experiments. In order to carry out exclusive experiments, the target thickness must be reduced by approximately an order of magnitude, making the acquisition of adequate statistics a serious problem. The fixed target e-A experiments have much greater incident beam intensity, however the beam energy has been limited to 30 GeV or less. The resulting COM energy is therefore below 7.5 GeV, greatly limiting the range of x and Q^2 that can be investigated. An appropriate e-A collider overcomes all of these difficulties. Figure 2 shows the range of x and Q^2 that have been covered by previous fixed target experiments. The vast range covered at HERA is only for *e-p* collisions, while the figure on the right shows the range that could be covered by an e-A collider with $s^{1/2}$ = 63 GeV (E_e = 10 GeV, E_A = 100 GeV/A).

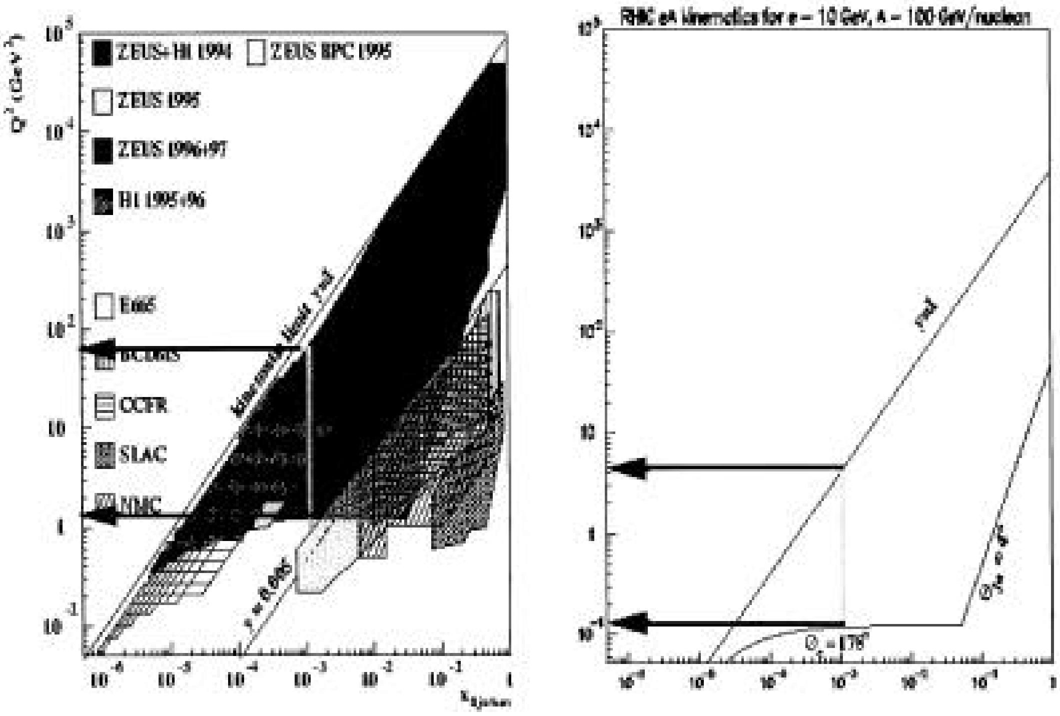


Fig. 2. On the left is shown the x and Q^2 coverage of previous experiments. The ZEUS and HERA measurements were only e-p. The rest are fixed-target experiments. The range of e-RHIC is shown on the right.

PREVIOUS STUDIES AND LUMINOSITY

Table I lists some of the previous studies of potential e-A colliders. A serious obstacle encountered in the previous studies has been the projected limited luminosity. The luminosities that had been projected for energetic e-A colliders were in the range of $l = 6\times10^{31}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$ per electron-nucleon. This luminosity was evaluated as interesting and useful but not compelling. The recent plans for both versions (EPIC and e-RHIC) of an electron-ion collider (EIC) propose to achieve $l = 10^{33}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$ per electron-nucleon [5]. This corresponds to 86 inverse pb per day and as previous studies established that significant physics results are obtained at 200 $(\mathrm{pb})^{-1}$ this is easily in reach with the proposed colliders. Achieving these luminosities requires electron cooling of the ion beam and an intense electron beam; the latter requirement is achieved already at the present day B-factories.

Table I. Previous attention to e-X colliders.

• HERA 30 GeV e on 800 GeV p
• Future Physics at HERA (1995-96) (e-A, e-p)
• GSI ENC (1997) (Seeheim Proceedings)
• Indiana University (1999) (EPIC 99)
• BNL e-RHIC 3 Workshops (December 1999, April 2000, June 2000)
• MIT-Indiana University, EPIC (September 14–16, 2000)

PARTONIC DISTRIBUTIONS IN NUCLEI

Table II lists some of the research areas that can be pursued at an e-A collider of sufficient COM energy. Due to the limited space available only a few these topics can be even briefly discussed. Recall that the conventional description of a nucleus is that of a collection of nucleons, weakly bound in a potential created by their mutual interaction. The underlying interaction is believed to arise from the exchange of virtual mesons between the nucleons. Thus it was a surprise when the NMC [6] found a systematic nuclear dependence to the nucleon's $F_2(x,Q^2)$ structure function. Their measurement of the structure function per nucleon as measured in Fe and ^{2}H showed definite nuclear dependence, only some of which is understood as of today. A host of dedicated fixed target experiments followed [7], confirming the existence of nuclear dependence but with some significant modifications of the original EMC results. This body of research has produced relative F_2 structure functions over a broad range of A, x, and Q^2. As the measured structure functions show regular and smooth dependence, only a few precise measurements of relative structure functions are required to characterize the nuclear behavior over the interval 2< A < 200. Figure 3(a) is a conceptual presentation of the current experimental knowledge of the $F_2^A(x)$ structure functions relative to the $F_2^d(x)$ structure function of deuterium. The rise at the largest values of x is generally ascribed to the nucleon's increased Fermi momentum. The enhancement and EMC regions presumably arise from nuclear binding effects but a quantitative explanation has yet to be developed [7]. The decrease observed for $x <$ 0.05 is termed shadowing and is the object of considerable attention as it has a strong quantitative impact on the outcome of relativistic heavy ion collisions [8,9].

Table II. Some research areas with an e-A collider.

• Extending x and Q^2 of nuclear parton distributions, $g^A(x)$ in nuclei
• Investigation of the saturation of parton density ?? (e-A, $x < 10^{-3}$)
• Diffractive processes, rapidity gaps, "Pomeron" (e-A, e-p)
• Time-space evolution of partonic processes (e-A)
• DIS semi-exclusive, exclusive underlying meson-baryon (MB) structure of nucleon, nuclear modifications of MB structure, skewed parton distributions
• Spin structure of the nucleon, extend $g_1(x,Q^2)$, $\Delta g(x)$ via 2-jet production

The $\gamma\!-\!p$ cross section for photon energies in excess of 2 GeV is only ~ 0.1 mb [10], which corresponds to a mean-free path in nuclear matter greatly in excess of 100 fm. Thus, one expected to observe the high-energy γ-A cross sections that were directly proportional to A. However, such was not the case as the cross section increases appreciably less steeply than A times the γ-*p* cross section. This is because the photon sometimes fluctuates into a $q\bar{q}$ pair which has a cross section typical of strong interactions (20 mb) and as such is often adsorbed and thus “shadowed” from the rest of the nucleus (even high energy neutrino-nucleus interactions evidence shadowing!). In QCD, shadowing in DIS is described in terms of the interaction of the $q\bar{q}$ color singlet fluctuations of the photon with target gluons. Most of the shadowing arises from pairs with large relative separation as they have the largest cross sections because their color is not well screened. These cross sections cannot be reliably calculated in perturbative QCD and hence some degree of phenomenology must be introduced to characterize the interaction. Shadowing effects are both significant and universal. They are best studied with DIS as the light-cone wave function of the photon’s $q\bar{q}$ pair can be characterized with high confidence. The coherence length of the $q\bar{q}$ fluctuation is $l_c \approx (2m_n x)^{-1}$. As the effects of shadowing set in as soon as the coherence length exceeds the internucleon separation distance in a nucleus of ~ 2 Fm, its onset is expected at x 0.05. Based on such a picture, shadowing should reach a limiting value when the coherence length becomes long compared to the nuclear diameter ($l_c > 2.4A^{1/3}$). The observation of this limit in heavy nuclei requires $x \le 10^{-3}$, which in turn requires $s^{1/2}$ of at least 60 GeV. Figure 3(b) shows the present data and makes it clear that better and more extensive data are required to investigate this region. The lowest *x* data shown in Fig. 3(b) comes from E665 and have Q^2 well below 1 GeV^2, and hence must be regarded with suspicion with regard to their interpretation.

Compared to the present knowledge of the *u*, *d*, and *s* quark distributions, the nuclear gluon structure functions ($g_A(x,Q^2)$) are effectively unmeasured. This is because leptonic probes do not directly couple to glue. The gluon distribution must be inferred from the change of $F_2(x,Q^2)$ with $\ln Q^2$ using the DGLAP evolution equations. This requires measurement of the relative $F_2^A(x,Q^2)$ of some characteristic nuclei to the better than 1% over a fair range in Q^2. In addition to providing direct information on shadowing, the relative yields are used to extract the ratio

$$R_{A,d}(x) = \frac{d\left[\dfrac{F_2^A(x,Q^2)}{F_2^d(x,Q^2)}\right]}{d\ln Q^2}\ , \tag{4}$$

which yields the relative gluon distributions. Such measurements are very difficult and have only been carried out in a single instance by the NMC [11]. Figure 4 shows the result of the measurement and the ratio of the gluon distributions extracted by Pirner and Gousset [12]. Figure 5 shows the projected statistical accuracy [13] that can be achieved in a 5-day measurement of relative gluon distributions between C and

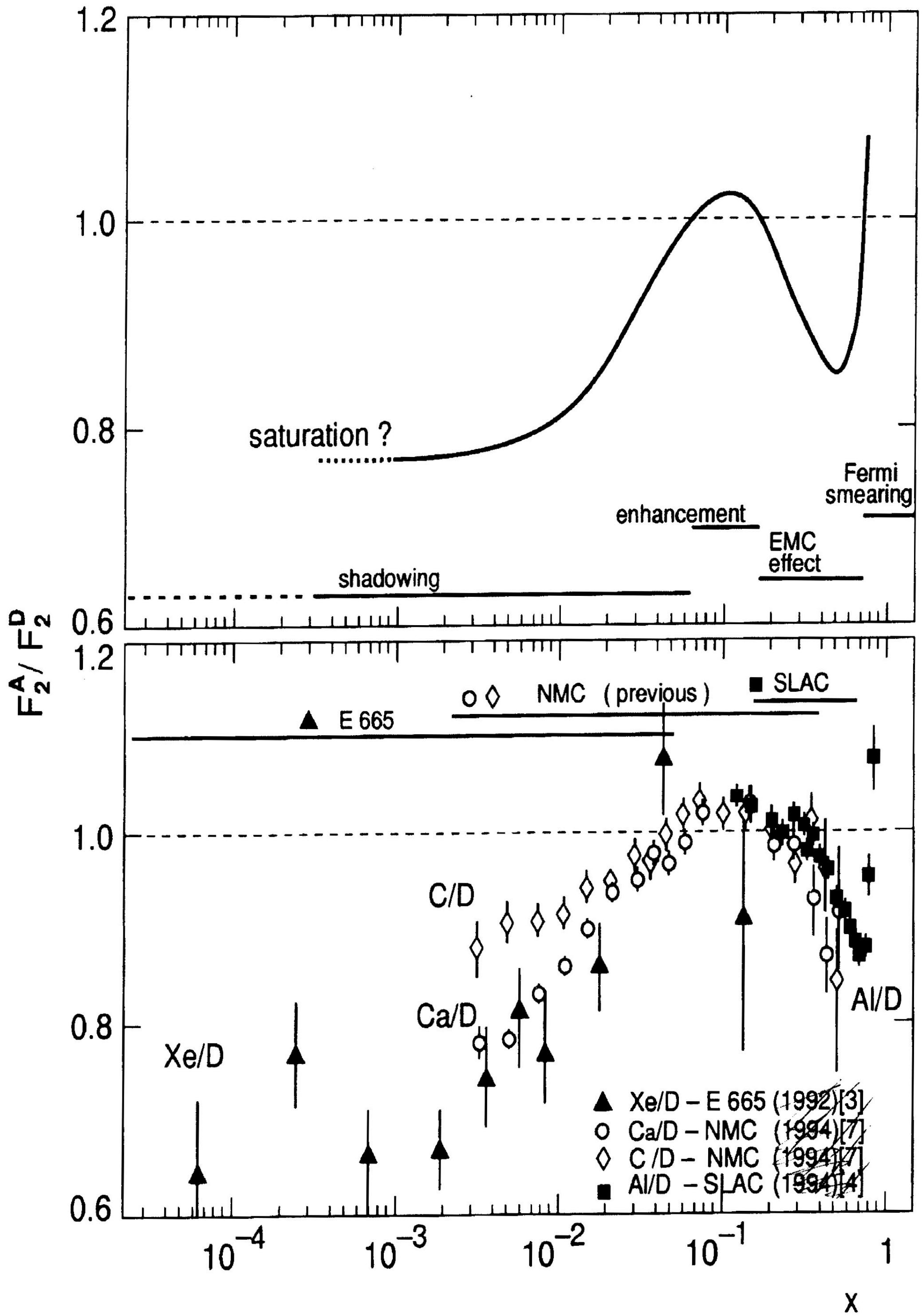


Fig. 3. The upper figure shows an idealized version of nuclear effects on the $F_2(x)$. The lower shows actual data for four cases.

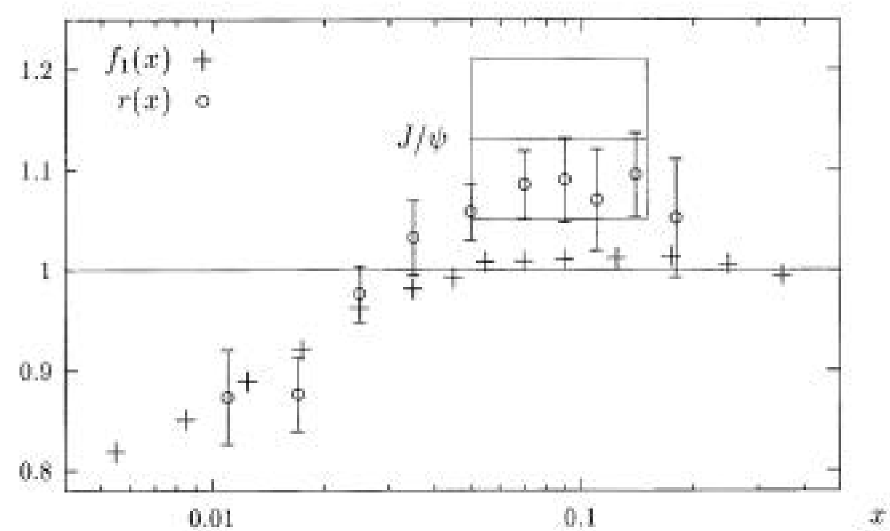


Fig. 4. The ratio $r(x) = G^{Sn}(x)/G^{C}(x)$ of tin to carbon gluon density as a function of x together with the ratio of structure functions $f_1(x) = F_2^{Sn}(x)/F_2^{C}(x)$. The box represents the extraction of r from J/ψ electroproduction data.

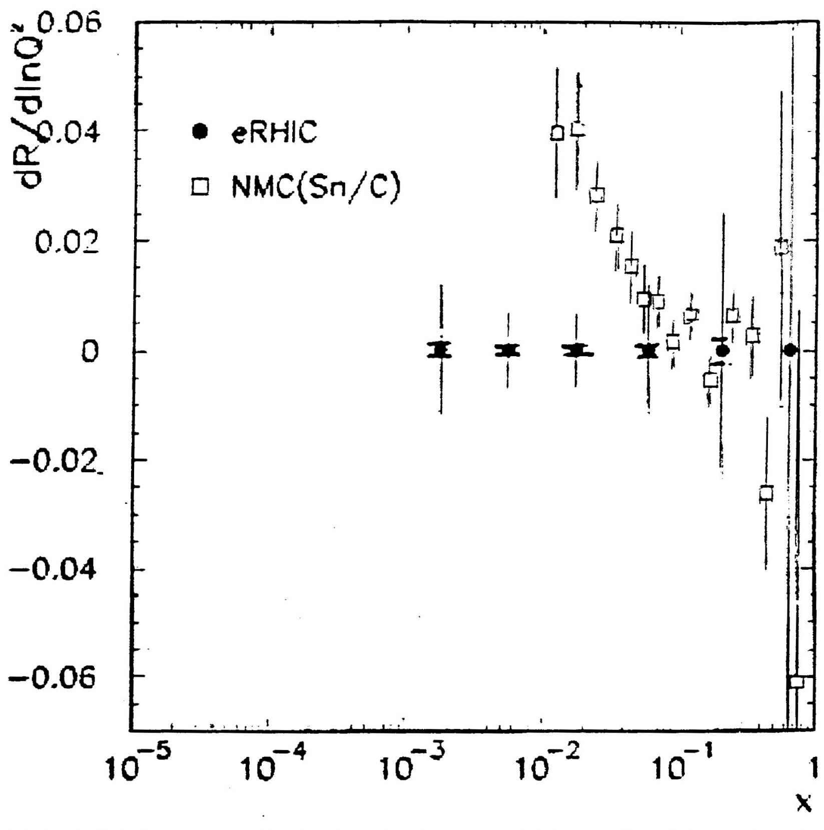


Fig. 5. Shows the statistical improvement that can be achieved at e-RHIC, with a 5-day run on $d(\mathrm{Sn}/\mathrm{C})/d\ln^2 Q$.

Sn. The issue in measuring this ratio to the required accuracy is not in obtaining adequate statistics, which is readily achievable with the projected luminosity, but rather reducing the systematic error below 1%. This challenge is common to many of the experiments envisioned for the EIC.

It is difficult to overemphasize the importance of shadowing on all high-energy processes occurring in nuclei. Shadowing plays a role in determining the final-state particle multiplicities and energy densities achieved in relativistic heavy ion collisions. Shadowing produces opacity effects that can mask color transparency in vector meson production, and the inability to properly characterize shadowing presently limits the extraction of partonic energy loss in the nuclear medium.

There is the possibility of reaching a new state of partonic matter – a saturated parton density – using an e-A collider. As shown in Fig. 6, studies at HERA [14] have shown that the gluon density grows rapidly at small x and high Q^2. This growth leads naturally to the question as to whether partonic densities eventually saturate. A great deal of theoretical work has been done on this subject, but there is no convincing evidence that such saturation has been observed in any experiment. At the saturation value the partonic matter would become black to strongly interacting projectiles. The DGLAP equations would become nonlinear due to parton-parton recombination. It is also clear that this saturated partonic matter is universal in the sense that it is independent of the system that spawns it. Figure 7 illustrates where in x and Q^2 such condensed partonic matter might exist. In the regime depicted in Fig. 7 the strong coupling constant α_s may be small enough that perturbative procedures may be employed. Mclerran and Venogopolan [15] have investigated a classical gluon field that models the saturated state. They find it has many of the properties of a glass, so they term the state a "colored glass condensate". e-A collisions play an important role in the search for and study of such a state by exploiting the fact that the longitudinal gluon density in a heavy nucleus is enhanced relative to that in a single nucleon. In the nuclear rest frame, an incident relativistic electron sees the nucleus contracted to a longitudinal diameter, $D_A = \gamma^{-1} 2.4 \mathrm{A}^{1/3}$. The valance quarks in the nucleons are contracted by roughly the same amount, as they carry equivalent momenta. However the low x partons in the nucleons carry much smaller momenta and hence are contracted to a much smaller degree. In fact, the gluons from different nucleons overlap in the longitudinal direction and present a gluon density that exceeds that of a single nucleon. For a nucleus with A nucleons the average enhancement factor is conservatively, $< R_A > / 2 = 3/8\ \mathrm{A}^{1/3}$, which for A = 200 is an enhancement of 2.2. Using the HERA data shown in Fig. 8, one sees that for Q^2 = 5 GeV^2 that $xg(x)$ increases by a factor of 2 between $x = 10^{-2}$ and 10^{-4}. Thus, increasing the gluon density by a factor of 2.2 is equivalent to the gluon density that would be found in the proton at an x that is $6 \cdot 10^{-3}$ times smaller. Thus, an e-Pb collision at $x = 10^{-3}$ at e-RHIC sees a gluon density that occurs at $x = 6 \cdot 10^{-6}$ in an e-p collision. Such a collision would require achieving $s = 2 \times 10^5$ GeV. Thus it is clear that an e-A collider with beams of nuclei with large A offer a considerable enhancement in investigating the interesting and important physics that can occur in a high parton density regime.

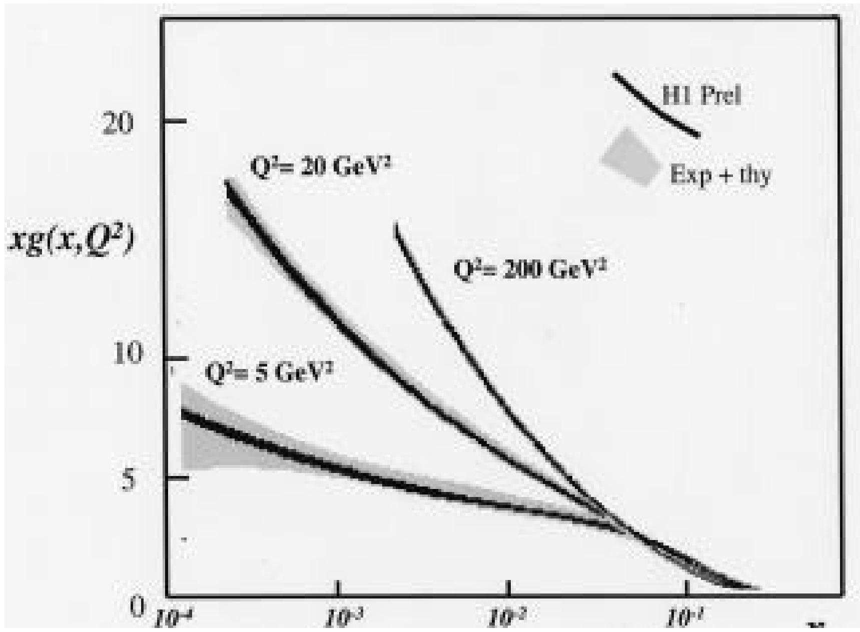


Fig. 6. $xg(x,Q^2)$ in the proton as a function of x for selected Q^2.

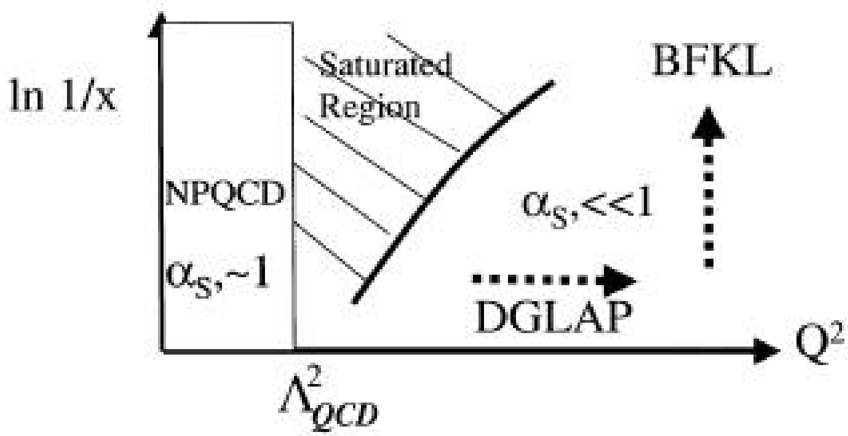


Fig. 7. Shows the region in x and Q^2 where a gluon condensate might occur.

DIFFRACTION

Diffraction is an important, many-faceted, and somewhat controversial subject. However, it is readily observable experimentally and represents a relatively large fraction (~10%) of the total cross section. There are several important issues to be investigated in the diffractive sector of e-A collisions. The structure of the Pomeron in nuclear matter can be studied, a posited intimate relationship between diffraction and shadowing [16,8] can be investigated, the nuclear gluon distribution can be determined via measurement of exclusive vector meson production, and various modes used to establish color transparency. The signatures for the identification of diffractive processes discussed below illustrate why a collider is usually essential to study many of its aspects.

Diffraction generally refers to hadron-hadron scattering where one of the hadrons more or less retains its identity. For example, a reaction such as p + p, leading to final states such as $x + p$, $x + n$, $x + \Delta$, $x + \Lambda$, etc., are regarded as diffractive when the leading baryon retains a large fraction (>95%) of the momentum of one of the colliding protons. The fact that the adsorbing hadron effectively retains its momentum leads to a coherence requirement that limits the invariant mass (M) of the diffracted state. For a particle of mass m and momentum p to diffract from a stationary target into a state of mass M, the minimum squared momentum transfer is

$$t_{\min} = \left(\frac{M^2 - m^2}{2p}\right)^2 \quad . \tag{5}$$

Thus, to retain coherence over a target of radius R, wave mechanics requires that

$$M^2 - m^2 \leq \frac{2p}{R} \quad . \tag{6}$$

For targets with R = 1 fm this requirement produces pronounced forward peaking (e^{-bt}) with $b = 8$ GeV^{-2}.

As a result of this peaking, the diffracted particle is well separated in rapidity from the target. Typically, an examination of the final state of the target is usually necessary to clearly identify diffractive processes. The exception to this observation is diffractive vector meson production. In this case the virtual photon either fluctuates into a vector meson which is diffracted off the target or into a $q\bar{q}$ pair that scatters onto mass shell by virtue of two gluon exchange with the target. One distinguishing feature of diffractive e-N scattering is the large rapidity gap between the target and any associated fragments. This is not expected in conventional deep inelastic scattering; in QCD the exchanged objects are always colored. Such an exchange leads to fragmentation making large rapidity gaps most unlikely.

Figures 8(a) and (b) show the signatures of diffractive processes observed in e-p scattering at HERA [14]. The signatures are found in the fraction of the beam momentum carried by the leading baryon. The diffractive events are well separated, carrying more than 97% of the beam momentum. Figure 8(b) shows that the extent of the rapidity gap associated with non-diffractive DIS falls rapidly below $\eta_{\max} = 2$, so events with $\eta_{\max}$ less than 2 may safely be taken to be diffractive.

Diffractive processes are typically described by the exchange of a quantity with vacuum quantum numbers, often referred to as a Pomeron. The fact that the Pomeron is colorless (color singlet) accounts for the observed rapidity gap. If a colored object (gluon, quark) were exchanged the rapidity gap would filled by string fragmentation. As the Pomeron is not part of perturbative QCD, its structure must be determined by

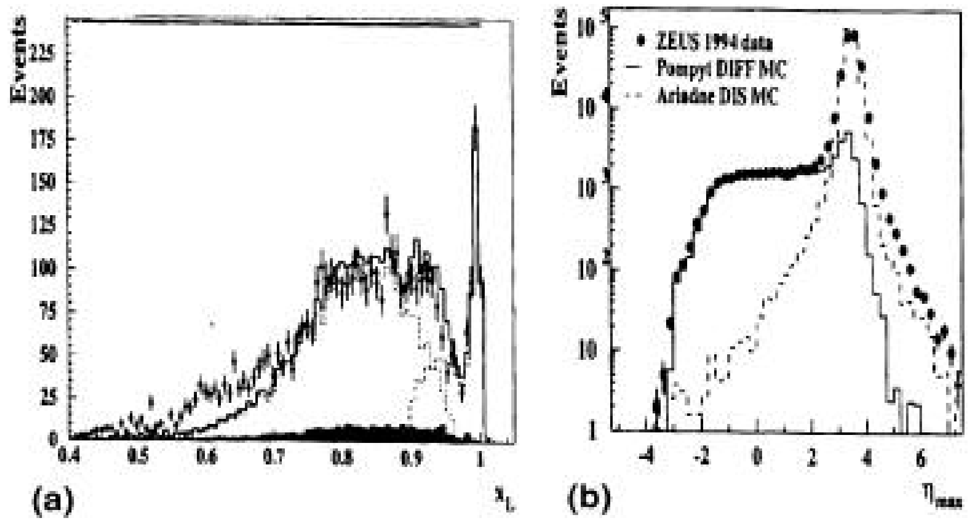


Fig. 8. (a) Shows the fraction of beam momentum carried by final-state protons. The diffractive events are at $x_L \leq 0.97$. (b) Shows the distribution of the maximum rapidity gap in DIS e-p events at ZEUS. For $\eta_{max} < 2$, the diffractive events dominate.

experiment. The Pomeron's Regge trajectory is expected to also contain the elusive glueball. Figure 9 depicts a diffractive e-p DIS where the proton does not change its state, the dotted double line represents the Pomeron. In the total set of DIS events there are many that also exhibit the properties of diffractive scattering. The set of parton densities associated with these diffractive events are labeled as

$$f_{j/B}^{D}\left(\beta, Q^2, x_{IP}, t\right), \tag{7}$$

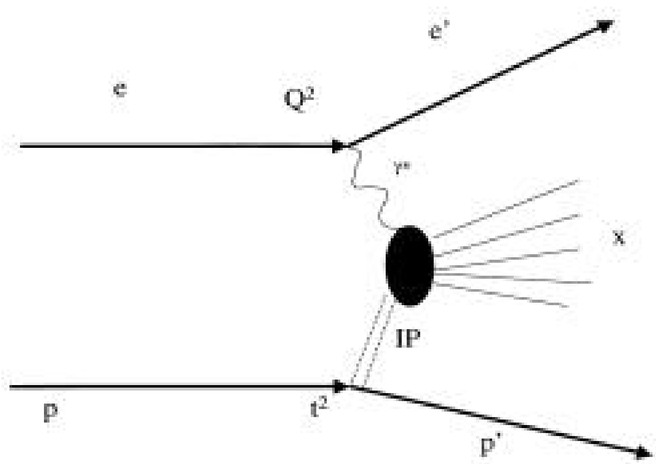


Fig. 9. Diagram of DIS off a Pomeron.

where $\beta = x / x_{IP}$. The outgoing baryon carries a momentum fraction $1 - x_{IP}$ and squared momentum transfer t. These events are used to measure the partonic content of the Pomeron. At HERA it is found [14] that the Pomeron is ~ 90% glue at $Q^2 = 4.5$ GeV^2, which decreases to ~ 80% at $Q^2 = 75$ GeV^2. It will be fascinating to see if there is any modification of this dominantly gluonic structure in the nuclear medium.

The principal interaction of the virtual photon's $q\bar{q}$ color singlet pair in the nuclear medium is with the nuclear gluons. The cross section for this interaction in the target rest frame is [17],

$$\sigma_{q\bar{q},N}^{\text{inel}}\left(E_{\text{inc}}\right) = \frac{\pi^2}{3} b^2 \alpha_s\left(Q^2\right) x g_N\left(x, Q^2\right) , \tag{8}$$

where $x = Q^2 / 2mE_{\text{inc}}$ and b ~ $3/Q$. This cross section grows rapidly with E_{inc} because of the rapid increase in the gluon density at small x, and increasing Q^2 as shown in Fig. 6.

In the special case where the final state is exclusive vector meson production, the photon's $q\bar{q}$ pair must couple to the target via the exchange of <u>two</u> <u>gluons</u> (see Fig. 10) and is thus sensitive to the square of the gluon density. Thus these experiments should be pursued because of their particular sensitivity to the gluon density. The different vector mesons (ρ, φ, ψ) provide a variety of final states that can be used in such studies. Of course, when nuclear targets are employed, final-state interactions must be considered. These final-state interactions are interesting in and of themselves as they involve issues such as color transparency. This is a rich area for study that extends all the way from diffractive di-jet production to exclusive vector meson production. Again the role of a high-energy e-A <u>collider</u> is critical to making progress.

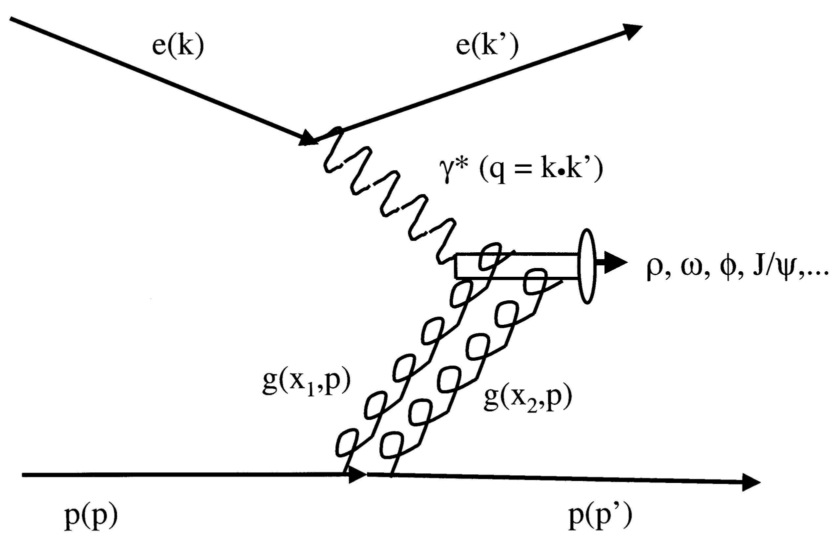


Fig. 10. Exclusive vector meson production in a QCD description.

TIME-SPACE EVOLUTION

As mentioned earlier, nuclear targets offer the only possibility of investigating the time-space evolution of partonic processes. This note has been full of examples of such evolution. Two further examples will illustrate the importance of the partonic interactions in the medium and the time space evolution of partonic state. The first example is the very large difference observed in the A dependence of acquired $< P_T^2 >$ of the final state di-muons from the Drell-Yan process as compared to those coming from J/Ψ and Υ production and decay [18]. Figure 11 shows this difference. The existence of a difference is not surprising, as only the incident quark undergoes strong interactions in the Drell-Yan process, while the vector mesons formed for the most part by gluon fusion suffer strong interaction both on the incident gluon and on the resulting cc pair. However, the fact that the difference is as large as a factor of 5 is difficult to account for. It is also noteworthy that the J/Ψ and Υ show the same effects, because the Υ is appreciably smaller than the J/Ψ and hence should experience weaker interactions in the medium. As a further example of time space evolution, Fig. 12 shows the A^{α} dependence of the J/Ψ and Ψ' cross sections observed in p $\rightarrow$ A reactions, as a function of x_F [19]. At small or negative x_F the velocity of the $c\bar{c}$ system is small enough that the J/Ψ and Ψ' have the time to form within the nuclear medium. The radius of the Ψ' is twice that of the J/Ψ so is more readily adsorbed as reflected in the Fig. 12. At larger x_F the $c\bar{c}$ emerges from the nucleus before either state has formed so they display similar nuclear dependence. Thus one can see that formation and coherence times are critical to understanding observed reaction yields. The study of such time space evolution is greatly enhanced in e-A collisions where the initial state can be characterized in its color content and transverse size much more effectively than in a hadronic collision. Low luminosity and low center-of-mass energy have greatly hampered the leptonic production and subsequent study of the evolution of $c\bar{c}$ pairs in nuclei. In addition to its intrinsic interest, the value it would add to the understanding the observed attenuation of $c\bar{c}$ states in p-A collisions and its use as a signature of QG plasma formation cannot be over emphasized at this time. Such studies become straightforward at e-RHIC and would greatly extend capability of investigating the time space evolution of many $q\bar{q}$ systems.

Limited luminosity and center of mass energy has not allowed a convincing demonstration of color transparency [4]. The present evidence is shown in Fig. 13. The notion of color transparency is fundamental to the concept of Bjorken scaling so it is important to demonstrate its existence and to quantify it. The increased luminosity and center of mass energy of e-RHIC will permit an investigation of a far greater range of Q^2, can use other vector mesons in addition to the rho (φ,J/ψ), and can provide far greater statistics than the earlier studies.

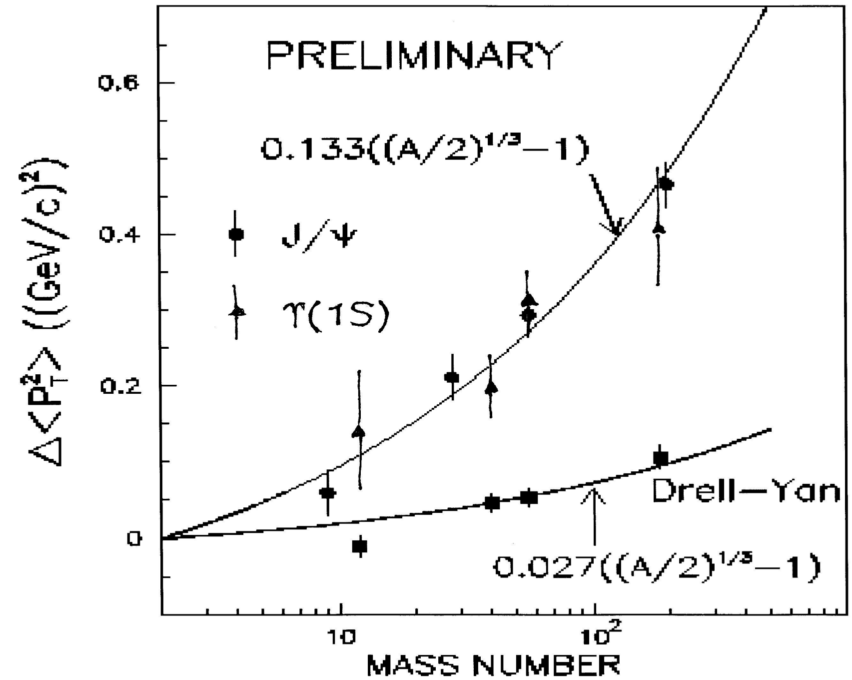


Fig. 11. The A dependence of the observed $< p_T^2 >$ of the final dilepton pairs in the Drell-Yan process relative to those from vector mesons.

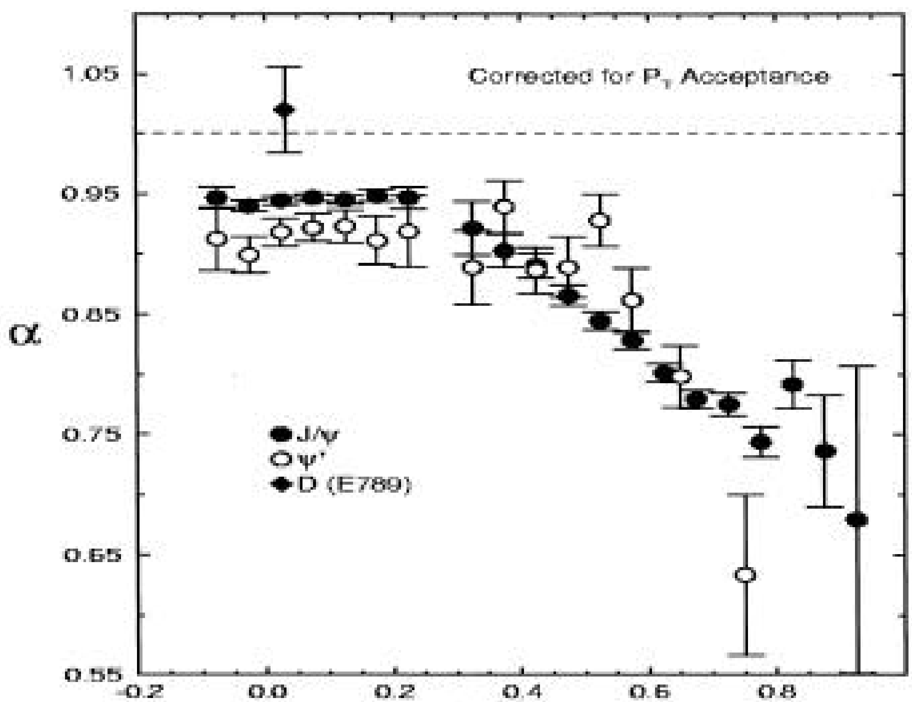
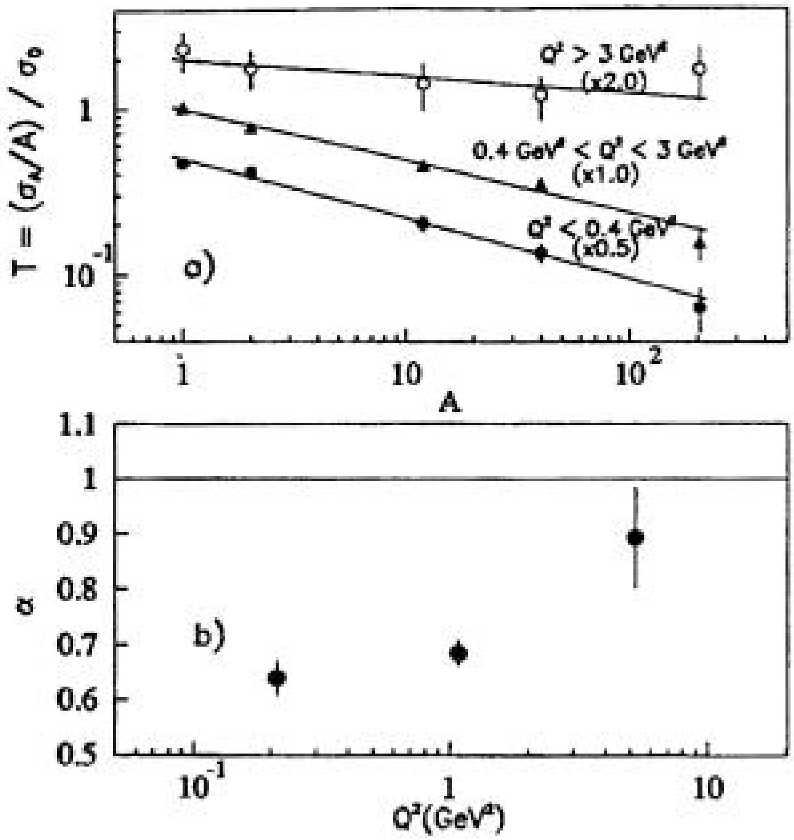


Fig. 12. Shows the A^{α} dependence of the J/Ψ and Ψ' yield as a function of $x_F \equiv x_1 - x_2$.



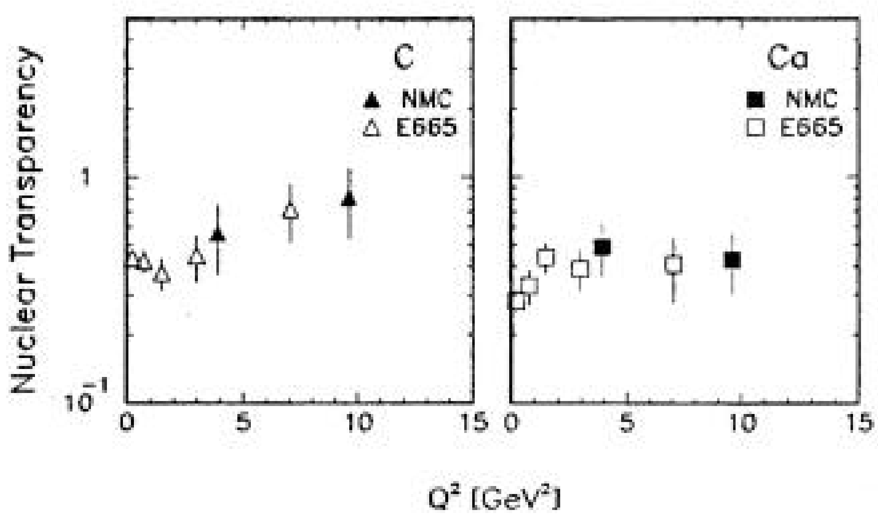


Fig. 13. The upper two diagrams show the evidence for color transparency from E665. The lower two figures compare results from E665 and NMC.

CONCLUSION

The above amply demonstrates the important, indeed critical role that a e-A collider can play in the investigation of the effects of the nuclear medium on the partonic structure of the nuclear constituents and on the time-space evolution of partonic processes. It should be obvious that such a collider is the most fundamental tool available for the investigation of this physics. Research at this facility should be full of surprises but results amenable to quantitative interpretation and incorporation into the rest of high-energy nuclear physics.

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